



NDCEE

National Defense Center for Energy and Environment

Cadmium and Hexavalent Chromium Free Electrical Connectors: A Synergistic Approach



DoD Executive Agent

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of the Army
(Installations and
Environment)

Robert B. Mason
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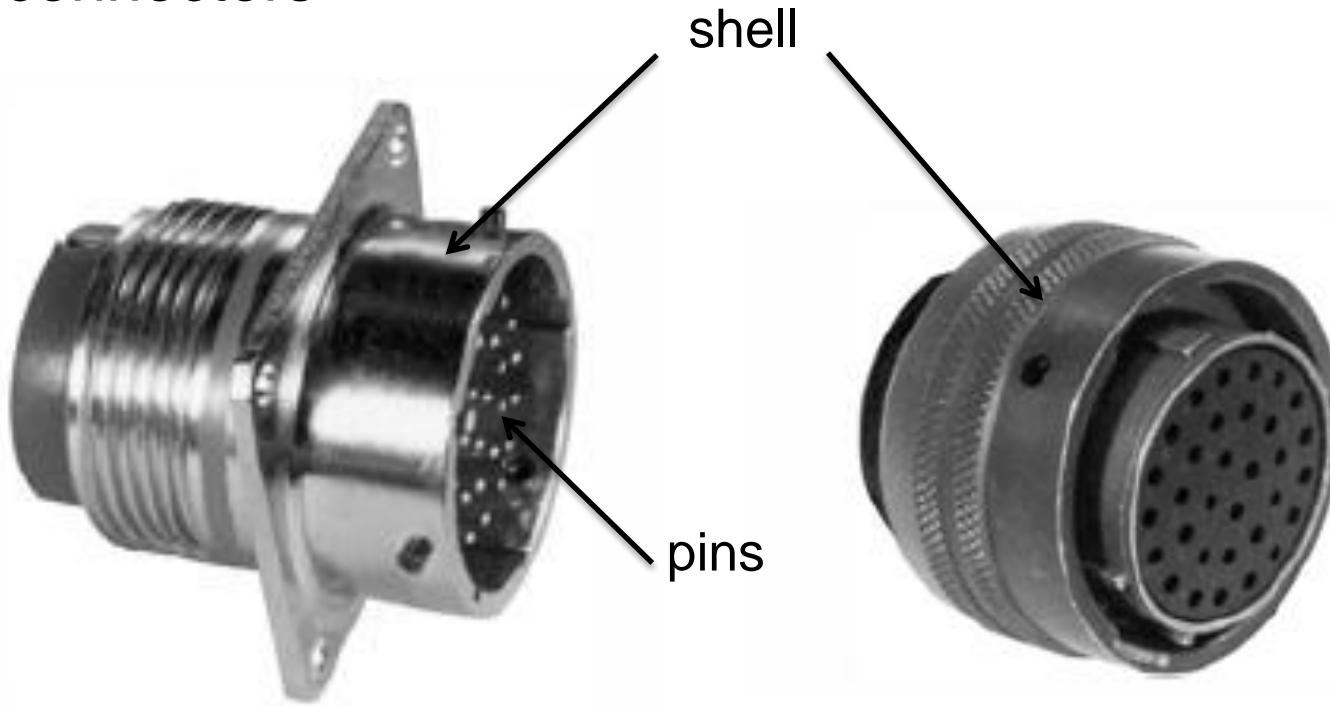
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Presentation Outline

- Background
- Overview
- Identification of Army's Electrical Connector Requirements
- Review of Previous Efforts to Identify Cadmium/Hexavalent Chromium Alternatives
- Development of Test Plan
- Status and Future Activities
- Summary

Background

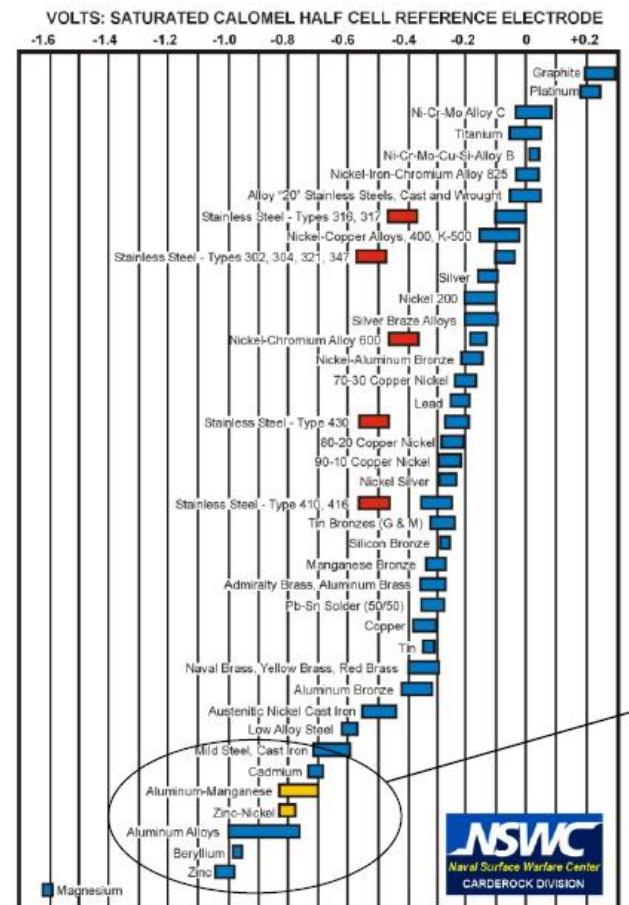
- Focus on shell coatings of military grade electrical connectors



- Receptacle (wall mounting)
- Plug (straight)

Background (continued)

- Shells currently coated with cadmium plating and hexavalent chromium topcoat
 - Imparts numerous engineering properties in synergistic fashion
 - Corrosion resistance
 - Ease of manufacturability
 - Electrical conductivity
 - Electromagnetic compatibility
 - Inhibition of algae growth
 - Lubricity
 - Repairability
 - Shock resistance
 - Solderability
 - Temperature resistance
 - Vibration resistance



Background (continued)

- Current and emerging regulations require consideration of alternative coating system
 - United States (U.S)
 - Executive Order (EO) 13423, *Strengthening Federal Environmental, Energy, and Transportation Management*
 - Requires Government agencies to reduce quantity of toxic and hazardous chemicals and materials acquired, used, or disposed
 - Cadmium regulated as Hazardous Substance, Hazardous Air Pollutant, Hazardous Waste, Toxic Chemical, and Priority Pollutant (Clean Water Act)
 - Restrictions from
 - Occupational Safety and Health Administration
 - Environmental Protection Agency
 - European Union
 - U.S. military systems exempt BUT could govern part availability in near future
 - Restriction of Hazardous Substances Directive
 - Waste Electrical and Electronic Equipment

Overview

- Purpose
 - Selection and testing of alternative coatings for electrical connectors used in U.S. Army ground systems
- Goals
 - Compliance with EO 13423
 - Compliance with other current and emerging regulations
 - Reduction of total life cycle costs of connector shell coating systems

Identification of Army's Electrical Connector Requirements

- Part numbers provided by TARDEC for four weapons systems
- Databases employed to obtain
 - Drawings (as available)
 - Procurement specification (as available)
 - Shell coating (cadmium, electroless nickel [EN], etc.)
 - Quantities procured (and dates)

Identification of Army's Electrical Connector Requirements (continued)

- Analysis – most commonly used connector types, by spec



CHAMPION: MIL-DTL-38999/26, class W
connectors

Review of Previous Efforts to Identify Cadmium/Hexavalent Chromium Alternatives

- Past Work to Demonstrate Alternatives
 - NDCEE
 - Strategic Environmental Research and Development Program (SERDP)
 - Environmental Security Technology Certification Program (ESTCP)
 - Joint Group on Pollution Prevention (JG-PP)
 - Joint Cadmium Alternatives Team (JCAT)
 - Defense Logistics Agency (DLA)
 - Concurrent Technologies Corporation (CTC)
 - Electrical Connector Manufacturers

Review of Previous Efforts to Identify Cadmium/Hexavalent Chromium Alternatives (continued)

- Findings - Viable Alternatives to Cadmium
 - Advanced Materials
 - Aluminum-Manganese Molten Salt Bath
 - Aluminum Deposited Through Chemical Vapor Deposition
 - Electrodeposited Aluminum (AlumiPlate®)
 - Electroplated Tin-Zinc (SnZn)
 - Electroplated Zinc-Cobalt (ZnCo)
 - Electroplated Zinc-Nickel (ZnNi)
 - Aluminum Deposited Through Ion Vapor Deposition
 - Metal-Filled Paints and Ceramics
 - Sputtered Aluminum

Review of Previous Efforts to Identify Cadmium/Hexavalent Chromium Alternatives (continued)

- Findings - Viable Alternatives to Hexavalent Chromium Topcoats
 - Trivalent chromium processes
 - Non-chromate processes
- *INITIAL* most promising cadmium alternatives for electrical connector applications
 - Electrodeposited Aluminum (AlumiPlate®)
 - Electroplated ZnCo
 - Electroplated ZnNi
- All three already approved for use on MIL-DTL-38999 connectors (*at least at first.....*)

Review of Previous Efforts to Identify Cadmium/Hexavalent Chromium Alternatives (continued)

- ZnCo removed from consideration
 - Questionable corrosion resistance, especially at high temperatures
 - Removed from MIL-DTL-38999
- SnZn added
 - Based on some previous promising results
 - Client requested non-nickel candidate
- Also added two types of EN-polytetrafluoroethylene (PTFE) processes
 - Already approved for use on MIL-DTL-38999 connectors
 - Do not require topcoat

Review of Previous Efforts to Identify Cadmium/Hexavalent Chromium Alternatives (continued)

- Data Gap Analysis
 - Electrodeposited Aluminum (AlumiPlate®)
 - Approved for MIL-DTL-38999 (and MIL-DTL-5015)
 - Cyclic corrosion testing not done
 - Some further durability testing would be useful
 - Other gaps identified but may be filled with 38999 qualification testing

Review of Previous Efforts to Identify Cadmium/Hexavalent Chromium Alternatives (continued)

- Data Gap Analysis (cont.)
 - Electroplated ZnNi
 - Approved for MIL-DTL-38999 (and MIL-DTL-5015)
 - Relatively mature process – lots of general data exists
 - Cyclic corrosion, durability, electrical and mechanical data are gaps
 - Dezincification has been an issue in past studies
 - Electroplated SnZn
 - *No approval for MIL-DTL-38999*
 - Prior data somewhat inconsistent
 - Older formulations did not yield consistent alloy composition
 - Newer formulations may have alleviated issue

Review of Previous Efforts to Identify Cadmium/Hexavalent Chromium Alternatives (continued)

- Data Gap Analysis (cont.)
 - Composite EN (with PTFE)
 - Approved for MIL-DTL-38999
 - Currently undergoing qualification testing (manufacturers)
 - Cyclic testing, other important parameters outside of 38999 testing not being considered
 - Galvanic corrosion resistance questionable

Development of Test Plan

- Substrates, coatings, post-treatments
 - Candidate connector: MIL-DTL-38999 Series III Class W
 - Also test panels as available and needed
 - One substrate - 6061 aluminum
 - Control: cadmium with hexavalent chromium
 - Five cadmium alternatives
 - Electroplated aluminum (AlumiPlate®)
 - Electroplated ZnNi
 - Electroplated SnZn
 - Composite EN (two types)
 - Two hexavalent chromium alternative post treatments
 - Trivalent chromium
 - Non-chromate post-treatment (as available)

Development of Test Plan (continued)

- Proposed tests – Phase 1 (testing as specified under MIL-DTL-38999)
 - Corrosion, Salt Spray
 - Electromagnetic Compatibility/Electromagnetic Interference Effectiveness
 - Fluid Resistance
 - High Temperature Resistance
 - Mating and Unmating Forces
 - Shell to Shell Conductivity

Development of Test Plan (continued)

- Proposed tests - Phase 2 (testing not specified under MIL-DTL-38999 but important to Army)
 - Corrosion, Cyclic
 - Corrosion, Scribed with Primer and Topcoat
 - Corrosion, Sulfur Dioxide
 - Durability in Humidity
 - Galvanic Corrosion Resistance
 - Lubricity
 - Wear/Handling

Status and Future Activities

- **Procure test specimens** April 2009
- **Initiate testing** April 2009
- Draft test report and submit March 2010
- Final report May 2010

Summary

- Current and future environmental regulations will restrict the use of cadmium and hexavalent chromium on electrical connector shells
- To meet this need, this effort has
 - Identified the most commonly used electrical connector design in the inventory (based on data sets provided)
 - Identified five promising candidates to replace cadmium
 - Identified two promising candidates to replace hexavalent chromium
 - Developed a test plan to assess candidate performance for this application
- Specimen procurement and testing is currently underway

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- **Government Technical Monitor** Ms. Parminder Khabra, TARDEC-RDECOM
- **Government Technical Advisor** Mr. Carl Handsy, TARDEC-RDECOM
- **NDCEE Project Manager** Ms. Margo Neidbalson, NDCEE

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For Further Information

Pam Khabra
U.S. Army TARDEC
Parminder.khabra@us.army.mil

Robert Mason
Concurrent Technologies Corporation
7995 114th Avenue
Largo, FL 33773
Phone: (727) 549-7246
masonr@ctc.com

NDCEE website:
<http://www.ndcee.ctc.com>

Thank you for your attention!



Questions?